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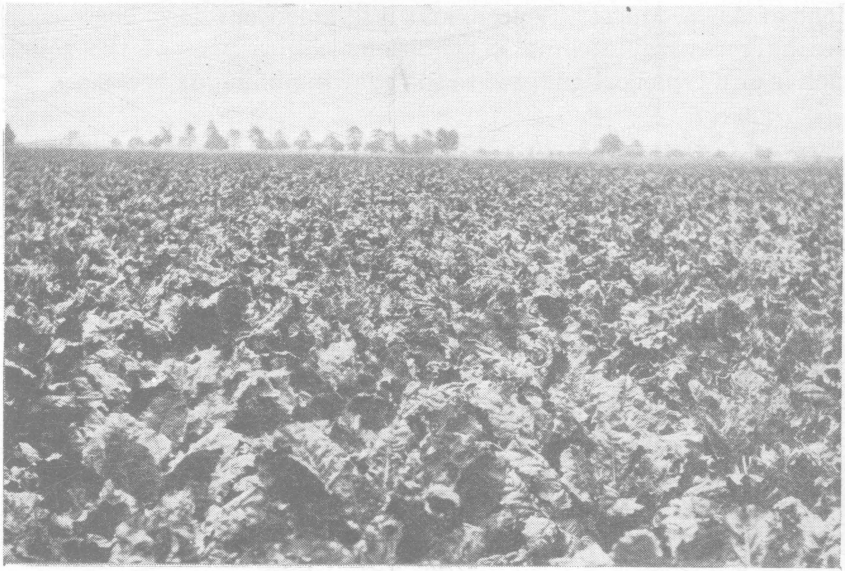

E. P. REED C. R. ARNOLD T. H. PARKS
Agricultural Extension Service, The Ohio State University

H. C. YOUNG
Ohio Agricultural Experiment Station

THE OHIO STATE UNIVERSITY, COOPERATING WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE,
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Sugar Beet Production in Northwestern Ohio

INTEREST in the sugar beet in Ohio dates from 1897. The first beet sugar factory was built at Fremont in 1900 by the Continental Sugar Company. The second was erected at Paulding in 1910 by the Columbia Sugar Company. During the next two years three more were established; one at Findlay by the Continental Sugar Company, one at Rossford by the Toledo Sugar Company, and one at Ottawa by the Ohio Sugar Company. Factories at Blissfield, Michigan, and at Decatur, Indiana, obtain a portion of their beets from Ohio.

Ohio Sugar Beet Area: The northwestern Ohio counties now growing sugar beets are Defiance, Fulton, Henry, Hancock, Lucas, Ottawa, Putnam, Paulding, Sandusky, Van Wert, and small portions of Allen, Mercer, Seneca, and Williams Counties. These counties have favorable climatic conditions, and a part of the soil in each is of a type best adapted to the growing of sugar beets.

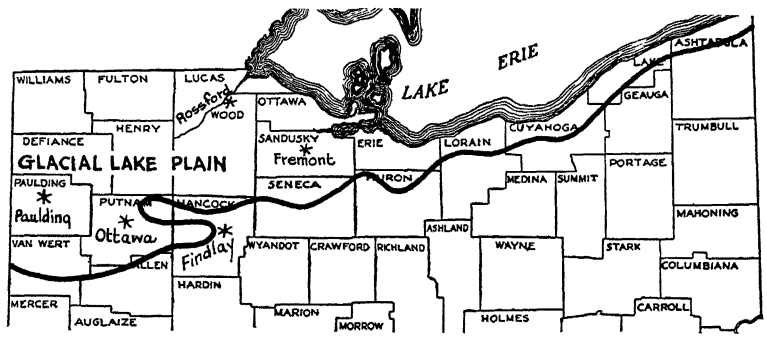

Fig. 1 defines the area in which most of the beets are grown. A large portion of this area lies in the "Glacial Lake Plain" or Maumee Valley.

The Sugar Industry

By C. R. ARNOLD
Extension Specialist in Farm Management.

THE world supply of sugar is secured chiefly from two sources, sugar cane and sugar beets. The world production of cane and beet sugar for the year ending June 30, 1929, was approximately 30 million tons, of which about 10 million tons was beet sugar, and 20 million tons was cane sugar. Sugar cane, which at present supplies about two-thirds of our total supply, is produced chiefly in India, Porto Rico, Cuba, Java, and small islands near the equator. Sugar beets, the source of about one-third of the world's sugar, are

* Locations of sugar factories.

grown primarily in central Europe and the north central part of the United States.

Before the war almost as much of the world supply of sugar was received from beets as from cane, but there has been a very rapid expansion of sugar cane production during the last fifteen years. Cane sugar production last year was almost double that of the five-year average before the war, 1909-1914, while beet sugar showed an increase of only fifteen per cent.

A very large percent of the sugar beets are produced in Germany, Russia, Czechoslovakia, Poland, France, and Italy. Production in these countries was very seriously affected by the World War, and for that reason beet sugar production decreased more than sixty per cent during the war period. This was the cause of our acute shortage and extremely high price of sugar near the close of the war. This was also the indirect cause for the great increase in sugar cane plantation development in many of the oceanic islands.

Following the war, the European countries soon went back to sugar beets, and their production is now above that of the pre-war period. As a result of this, together with the increasing production of the greatly expanded sugar cane acreage, there has been an abundance of sugar in the world during the past few years.

The wholesale price of sugar in New York increased nearly 300 per cent during the war period, but in the last year or two the price has been about the same as during the pre-war period from 1909 to 1914, even though the average price of all commodities is about 50 per cent higher now than before the war. With the large investments in the sugar cane plantations and the adaptability of Europe for beet sugar production, there appears to be no reason for any world sugar shortage in the near future.

The Position of the United States in Sugar Production and Consumption

Less than 20 per cent of the total amount of sugar consumed in this country is produced in continental United States. A large quantity is brought in from our island possessions, but the imports from other countries amount to more than one-half of our total supply. Practically all of our imports from foreign countries come from Cuba because of the preferential tariff rate with that country. Consumption of sugar per capita in the United States increased steadily until 1925, but has shown a slight tendency to decrease since that time. The average annual consumption of sugar in the United States is now about 110 pounds per capita.

Sugar Production in Ohio

About one-third of all the sugar beets produced in the United States are grown in Colorado alone. Colorado, Nebraska, Utah, and Michigan are the leading states, and during the five years 1925 to 1929, these four states produced just about two-thirds of the total beet crop of the United States. Ohio supplied only 4 per cent of the total during this time.

There has been a rather definite tendency to increase the acreage of sugar beets during the last few years in Colorado, Nebraska, Montana, and Wyoming, with a similar tendency to decrease in some of the eastern corn belt states. This decreased acreage is most noticeable in Wisconsin, Michigan, and Ohio, where the acreage in 1929 was less than one-half as large as in 1924 and where the average yield per acre is much lower than in the western states. The sugar beet acreage in Ohio in 1929 was the lowest since 1914, but it increased in 1930.

The Place of Sugar Beets in the Organization of Northwestern Ohio Farms

Although the acreage which can successfully be devoted to sugar beets in northwestern Ohio is limited by climate and soil type, there are thousands of farms in that section upon which neither of these are limiting factors. Many of these farms could add sugar beets as another enterprise of their farm business. This must be decided for each individual farm, and based on the changes which the added enterprise would make in the organization of the rest of the farm business and the influence on the net farm income from all enterprises for the entire year. Decisions of this type should be based on the values per acre of the different crops, the cost of producing sugar beets, distribution of labor on beets and the conflict with labor for other crops, size of farm business and overhead expenses, and fitting sugar beets into the farm organization program.

1. *Value per Acre of Different Crops.*—The gross value of sugar beets per acre based on average yields and an average price is higher than that of any other field crop grown extensively in northwestern Ohio. Alfalfa is second, followed closely by corn. The gross value of the small grains per acre is much lower. One average acre of sugar beets gives a gross return equal to that from 2 acres of corn or 4 acres of oats. However, the cash expense for growing an acre of sugar beets is much above that for other crops. After all cash outlays for contract labor, seed, fertilizer, and other usual costs are deducted, an acre of sugar beets gives a larger net return

than other common crops in that section. Corn, alfalfa, wheat, barley, and oats follow in the order given. The difference in favor of sugar beets, however, is not as great as was shown in the gross returns per acre, since the beets require much more cash expense than the others.

Corn is ordinarily considered as the crop of highest profit throughout western Ohio and usually commands preference over other crops, but these figures indicate that an average crop of sugar

Fig. 2.—A modern sugar-beet factory.

Comparison of Gross Value and Value Above Cash Costs of an Average Acre of Different Crops in Northwestern Ohio

	Gross value per acre based on average yields and average prices for Northwest Ohio	Value per acre after cash outlays are deducted*
Sugar Beets	$56.00	$30.40
Corn	29.00	27.60
Alfalfa	30.00	24.50
Wheat	21.25	16.85
Barley	17.50	14.40
Oats	14.00	11.10

* Based on complete cost account data from Putnam County, 1926 to 1928.

beets compare quite favorably with corn as a cash crop. Sugar beets are necessarily sold as beets, but corn may be either sold or fed. The return which good livestock will pay for corn which is fed may often place the net return from an acre of corn above the figures given here. The price of sugar beets has been more dependent upon the tariff rate than the price of other farm crops common to this section.

2. *Cost of Producing Sugar Beets.*—Cost of production figures from 116 farm records in northwestern Ohio covering a 5-year period from 1924 to 1928 show an average cost of $6.41 per ton. This includes a charge for the use of land, machinery, man labor, horse labor, and all cash expenses such as contract labor, seed, and fertilizer. This total cost per ton is below the average price received during those years.

Sugar Beet Costs—Northwestern Ohio

Year	Number of farm records	Average yield per acre	Average cost per ton
1924.....	35	7.4 tons	$7.77
1925.....	24	11.9 tons	5.69
1926.....	32	10.9 tons	5.75
1927.....	9	10.7 tons	6.02
1928.....	16	9.7 tons	6.01
Total.....	116		$6.41

The average yield per acre, which is an important factor in holding down the cost, was above average on these 116 farms from which cost records were secured. It is interesting to note that the average cost of producing corn on 20 farms in Putnam County during the three years from 1926 to 1928 was 55 cents per bushel. These men also received yields of corn far above the average for all farms in this entire section. Thus our best information on cost of production indicates a cost of $6.41 per ton for beets selling around $7.00 and a cost of about 55 cents per bushel for corn selling near 70 cents per bushel. Relative profitableness of sugar beets compared with other crops based on cost of production and value of the crop per acre apparently do not give a full explanation of the downward trend in sugar beet acreage in northwestern Ohio.

3. *Distribution of Labor on Beets Throughout the Year and Conflict of Labor on Different Crops.*—Cost accounts on 20 farms in Putnam County, Ohio, show that the labor required on an acre of corn was 25.9 hours compared with 27.7 hours on an acre of sugar beets, not including contract labor. Although this difference is not great, one of the most serious problems which has con-

fronted farmers who raise beets has been the conflict in the seasonal distribution of labor on sugar beets and corn. A large part of the beets follow corn in the rotation, which usually necessitates spring plowing. The following charts show the actual distribution of labor, on corn and that applied to beets on these Putnam County farms.

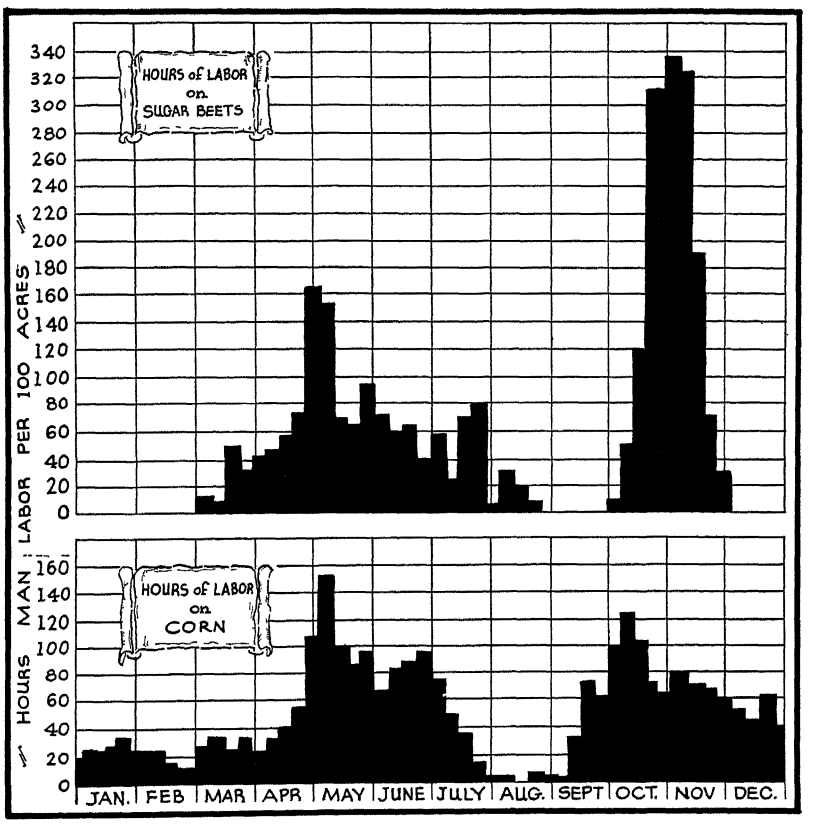

Fig. 3.—Weekly distribution of labor on corn and sugar beets in northwestern Ohio. Earlier planting of beets would distribute the labor more evenly.

This shows that the rush period of spring work comes at about the same time on both crops under methods which are now followed in that section. Present recommendations from soils and crops men state that beets should be planted earlier. If this could be done either through fall plowing or some other method which would allow the rush period of beet planting to be out of the way ahead of the rush at corn planting time, one of the serious handicaps to beet growing would be greatly reduced.

4. *Size of the Farm Business and Overhead Expenses.*—At the present time one of the most important factors affecting Ohio farmers' incomes is the small volume of business on many farms. During the last fifteen years, taxes and other overhead expenses have advanced very rapidly, and many farmers following old farming methods do not carry on enough business during the year to cover these expenses and allow any return for the unpaid labor. Sugar beets offer a means of farming more intensively, especially the portion of them which are substituted for small grains or crops of a low acre value (provided these are crops which are to be sold and not fed). Taxes and interest on an acre of land will be about the same regardless of the value of the crop produced from it.

Although sugar beets require some special equipment, they are hauled directly from the field to market, so the overhead costs of equipment and buildings for each acre of sugar beets is not large. Because of the overhead equipment costs, an extremely small acreage per farm usually shows a higher cost per acre than where a larger acreage is grown.

5. *Fitting Sugar Beets Into the Farm Organization Program.*—Many farmers in northwestern Ohio could profitably place sugar beets in their farming organization, even at the low prices of the last few years. Whether or not any farmer should begin to raise beets will depend upon his labor supply, the present labor distribution on other crops, the profitableness of the crops for which the beets would be substituted, the distance from the loading station, and any other factors which will tend to raise or lower the net income from the entire farm business.

Factors Influencing Production of Sugar Beets

By E. P. Reed
Extension Specialist in Soils and Crops

The most important natural factors influencing commercial production of sugar beets are: climate, soil, topography, water supply, and drainage. Other factors limiting the yield are: crop rotation, time of plowing, seedbed preparation, application of fertilizers, blocking and thinning, cultivation, insects and diseases, harvesting, and the supply of hand labor.

CLIMATIC CONDITIONS

The most favorable climate for sugar beets has an average temperature of 70° F. during June, July, and August. Ohio's nearest approach to this occurs in about the northern third of the state.

When the growing season is much warmer than this, the beets have a sugar content lower than is commercially profitable.

Sunlight is important because leaves cannot manufacture sugar in the absence of light. The sugar is all made in the beet leaf through the action of light on the leaf-green, in the presence of moisture and carbonic acid gas. Very early in the growing season, the young beet plant begins to store sugar. While the beet root is increasing in size, a large portion of the sugar is used for growth purposes.

As the beet nears maturity the difference in temperature between day and night is important. Apparently cool nights and warm sunshine during the day are conducive to the maximum storage of sugar in the root. Sugar beets are injured by freezes in the spring, just after they have germinated, but are little affected by light frosts in the fall.

An adequate supply of moisture during the growing season is essential. The ideal sugar beet season has a rainfall sufficient to maintain a steady growth until near harvest time, followed by fair weather (cool nights and warm days), a condition most favorable for sugar beet production. The average annual rainfall in northwestern Ohio is 33 inches and is usually well distributed. It is sufficient to supply the moisture for maximum production of sugar beets.

So far as climate is concerned, sugar beets are best adapted to the area along the northern edge of the corn belt, and it is easily possible to locate, in northwestern Ohio, a million acres that will grow beets successfully. At present, less than 4 per cent of the area that is favorable for sugar beet production is utilized for that purpose.

SOIL REQUIREMENTS FOR SUGAR BEETS

Although the beets will grow on many types of soil, a high yield of beets with a desirable sugar content is confined to a limited area of the state. In northwestern Ohio these soils are mostly of old Glacial Lake formation and in topography are flat or slightly undulating. Sugar beets are sensitive to acid soil conditions, and therefore are not grown commercially in the eastern half of the state. Beets require a well-drained soil of good productivity.

While many soils which meet these requirements will raise good beets, the soil region in Ohio best adapted to the growing of sugar beets is made up of clays and clay loams. By far the largest area is the Brookston clay which, to a depth of 6 to 8 inches, has a dark gray color and contains a small amount of grit. Locally this

is known as "elm land" and occurs in the "black swamp" areas. Some phases of this soil are much heavier than others. While the percentage of clay is quite high, the soil is granular and somewhat friable, possessing a good crumb structure.

The subsurface is of mottled, heavy, plastic clay, ranging in color from dark drab to dingy yellow and containing some sand and occasional fragments of gravel. This is distinctly heavier and more plastic than the surface soil, but lacks the smooth, greasy feel characteristic of the Toledo silty clay which is the second most extensive soil suited to beet production.

The surface 6 to 8 inches in the Toledo silty clay is dark gray to black, heavy, silty, clay loam to silty clay. Its subsoil is, in color, a lighter bluish gray than the Brookston clay and the yellow gradates into a rusty brown tinge. These soil types have the ability to retain sufficient moisture through temporary dry spells during the summer to maintain a steady growth of the beet plants.

The Brookston and Toledo clay loams are well adapted to beets, but are of limited extent. Sugar beets are also grown on other types of soil that occur in small areas within the limits of the darker colored soils. These are mostly light colored and light sandy soils that are well drained. While the yields on the light soils are smaller and quite variable, the percentage of sugar contained is usually high. Very few, if any, beets are grown on muck soils in Ohio. Large yields are obtained on such soils, but the beets are usually low in sugar content.

Summarized, the soil requirements of sugar beets are:

1. It must be naturally a soil of high fertility.
2. It must be well balanced as to elements of fertility.
3. It must be well supplied with carbonate of lime.
4. It must have a high water holding capacity.
5. It must have good drainage.

SOIL PREPARATION FOR SEEDING

Both horse and tractor drawn plows have been designed to turn the furrow slice properly on any type of soil. Many experienced plowmen fail to do satisfactory work because their plows are not adjusted to meet the condition of the soil, or are improperly hitched, causing them to cut too wide or too shallow a furrow. When the soil is not properly turned and a thorough coverage of trash and stubble obtained, no subsequent cultivations will produce a satisfactory seedbed for maximum plant growth.

Fall Plowing.—In Ohio, on the heavier beet soils, fall plowing is advisable. However, it is not possible where the beets follow

corn in the crop rotation, unless the corn has been harvested for silage. Fall plowing allows the soil to settle and is conducive to a more rapid decay of the stubble and trash turned under. Insects, especially cutworms, are less troublesome in fall plowed sod ground. In addition, winter freezing and subsequent thawing leaves the surface soil mellow and in a good workable condition. Plowing in the fall can be done with a tractor, because precaution to avoid packing the soil is not necessary at this time of the year. Tractor-drawn plows usually do much better work than those

Courtesy of U. S. Department of Agriculture.

Fig. 4.—Deep plowing with all trash well covered is essential for successful beet culture.

drawn by horses, due to their increased rate of speed and the evenness of depth maintained.

Spring Plowing.—Spring plowing for beets in Ohio is the more common practice, as a greater acreage of beets follows corn than any other crop. Many farmers grow their beets after corn, for the reason that there is usually less insect and disease damage following a clean-cultivated crop than following green legumes such as alfalfa and sweet clover, or sod ground, spring plowed. The heavy soils adapted to beet growing, when spring plowed, must be at their optimum moisture content or they become lumpy and will remain so throughout the summer. In order that the beets may be seeded at the proper time, the spring plowing must be started

early or at a time when the soil does not pack. Sometimes it is preferable to use horses at this time of the year, although many growers wait until the soil is sufficiently dry to permit using the tractor. This may or may not be a good practice, as at this late season it may be impossible to firm the soil properly because of lack of rainfall.

The disadvantages of spring plowing may be partially offset by preceding the plowing of loose or stubble ground with a thorough disking. The disking will break up the surface layer, preventing lumpiness and the forming of air spaces where clods are turned to the bottom of the furrow or where one furrow slice overlaps another. The disking thus makes it possible for a more uniform plant growth, which results in a better shaped beet.

Depth of Plowing.—The depth of plowing should vary with the depth of the surface soil or plow layer. In some of the beet areas, the surface soil ranges in depth from 6 to 7 inches, and in a few places from 8 to 9 inches. Unless the practice of deeper plowing has been followed for a number of years, it is not advisable to plow up more than ½ inch of the subsurface soil at any one time. An exception to this condition would be in a soil containing an abund-

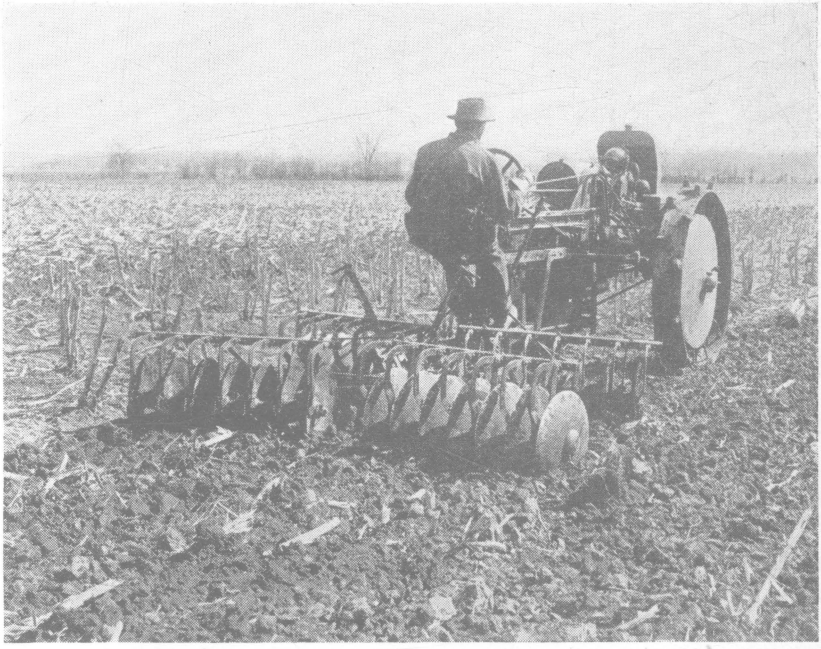

Fig. 5.—Disking before plowing breaks up the surface soil, avoids excessive air spaces, and results in a finer and firmer seedbed.

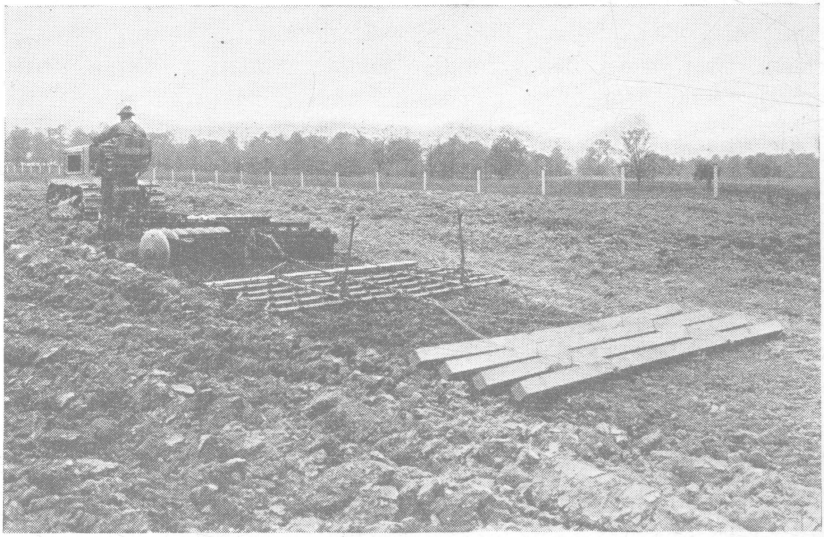

Fig. 6.—Following the disk and harrow with a plank-float levels the surface and pulverizes the small lumps.

ance of organic matter or plant food. A large admixture of subsurface soil may affect the tilth of the surface soil so much that maximum plant growth would not be possible.

For the best development of the beet root it is desirable to have the surface soil layer extend to a depth of 9 or 10 inches. This depth may be obtained safely by gradually increasing the depth of plowing and by growing in the rotation deep-rooted legumes, such as alfalfa and sweet clover.

SEEDBED PREPARATION

A well-prepared seedbed is essential for a maximum beet yield. The soil must be firm to conserve moisture, and to have a fine surface for even depth of seed coverage and to insure uniform germination.

Spring plowed ground should not be left to dry to the depth plowed before it is worked down. The ground, when dry enough not to pack, should be disked thoroughly and the disk followed by cross harrowing and a plank float to level the surface and pulverize the small lumps. If these operations do not fine and firm the soil sufficiently, the cultipacker is run over the ground just ahead of the seeding drill. It is well to remember that a properly prepared seedbed is one of the necessary steps to insure a good beet crop.

Plant Food Removed by Crop.—Contrary to the opinion, once general, that sugar beets remove large quantities of plant food from the soil, the reverse has been found true. While beets take out of the soil the same elements that other crops remove, they are in slightly different proportions. Yet a large part of the mineral element is in the beet top, and can be returned to the soil so that there is little loss of plant food.

Fig. 7.—Cultipacking the soil ahead of seeding firms the soil so that a more uniform coverage and germination of seed is obtained.

*Mineral foods removed from soil by different Crops**

Crop	Yield tons or bus.	Nitrogen, pounds	Phos. Acid, pounds	Potash, pounds
Sugar Beets.....	10 tons	30	14.0	70.0
Potatoes.....	6 tons	47	21.5	76.5
Wheat.....	30 bus.	48	21.1	28.8
Barley.....	40 bus.	48	20.7	35.7
Oats.....	45 bus.	55	19.4	46.1
Corn.....	40 bus.	56	21.0	23.0
Red Clover.....	2 tons	102	24.9	83.4

* Harris and Butt, Utah Circular, No. 34.

This table shows that, in comparison with other crops, sugar beets use relatively more potash than nitrogen and phosphoric acid. In considering the rotation as a whole, and for Ohio soil conditions, there is not yet sufficient evidence that an application of fertilizer containing a greater percentage of potash than phosphoric acid would be the most economic in the growing of sugar beets. There is, however, sufficient experimental evidence to justify the use of a larger total amount of potash than is now commonly applied to the beet crop. Under certain conditions, potash may so stimulate the growth of the beet plant that the beet root is less liable to be affected by diseases. The potash may also materially increase the sugar storage.

Manure.—Yard or stable manure is seldom applied directly to the beet crop. Manure is sometimes plowed under for beets if the preceding crop has been hay pasture or small grain, and applications of well-rotted manure will benefit the beet crop. The general practice of applying the manure for the corn is more commendable. Since, in the majority of rotations, beets follow corn, the manure is utilized to a better advantage. This method permits the fibrous material to become well rotted and the weed seed contained is germinated and destroyed in the process of corn cultivation, leaving a clean soil for beets.

Commercial Fertilizers.—Use of fertilizer on beets is a common practice. Formerly most of the fertilizer, 75 to 125 pounds per acre, was applied in the row at seeding time. Later, as the rate of application increased, a part of the fertilizer was broadcast. Numerous tests and experiences have proved that profitable yield increases result from larger fertilizer applications. These increased yields are brought about by providing an adequate supply of readily available plant food in the soil for the beets during the entire growing season. The vitality of the beet plant is stimulated, thus producing a rapid growth which enables the beet to take advantage of the spring moisture supply and to resist disease and insect attacks.

Various amounts and combinations of the different fertilizer elements have been used during the past years. A summary of results indicates that the presence in the soil of available forms of nitrogen, phosphorus, and potassium are essential for maximum beet yields. The amount of these elements needed is contained in an application of 400 to 600 pounds per acre of the recommended standard fertilizer analyses.

Fertilizer Recommendations.—The fertilizer broadcast, should contain both phosphorus and potash; the row application nitrogen,

phosphorus, and potash; and the side dressing nitrogen only, in the following amounts:

Application per acre	Analysis	Method of application
200 to 300 pounds.....	0-12-12	Broadcast
100 to 150 pounds.....	4-10-6	In row
100 to 150 pounds.....	Nitrogen carrier	Side dressing

Where no fertilizer is broadcast or side dressing applied, the use of 150 to 200 pounds per acre of 4-10-6 in the row is recommended. The broadcast fertilizer application preferably follows the disking of the plowed ground, thus insuring a more thorough mixing with the soil during subsequent cultivations. The side dressing

Fig. 8.—Fertilized beets (on the right) yielded 3.5 tons per acre more than the unfertilized (on the left) on this Hancock County field.

of available nitrogen (preferably in the nitrate form) is applied immediately following blocking and thinning operations. Numerous field tests have shown that the beet yield may be increased from 2 to 3 tons per acre when nitrogen side dressings have been applied.

Early Seeding Increases Beet Yield

Date of Planting.—Records kept by sugar companies show conclusively that the date of planting has a direct influence on the yield of beets. At the present time the average planting date of beets is twenty days too late to obtain maximum yields. In Putnam County beets planted ahead of the corn gave higher yields than those

planted after corn. Data accumulated by the Continental Sugar Company show that beets planted before May 10 yielded 3 tons per acre more than beets planted after May 31.

Early planting not only obtains a higher yield but maintains an even distribution of labor as the preparation of the seedbed would occur following spring grain seeding, and the planting immediately preceding corn planting. Sugar company representatives state that there is no advantage in attempting to distribute the planting season in order to facilitate the factory management, as the planting season naturally spreads over a considerable period, and soil and weather conditions may result in the different plantings maturing for harvest at the same time.

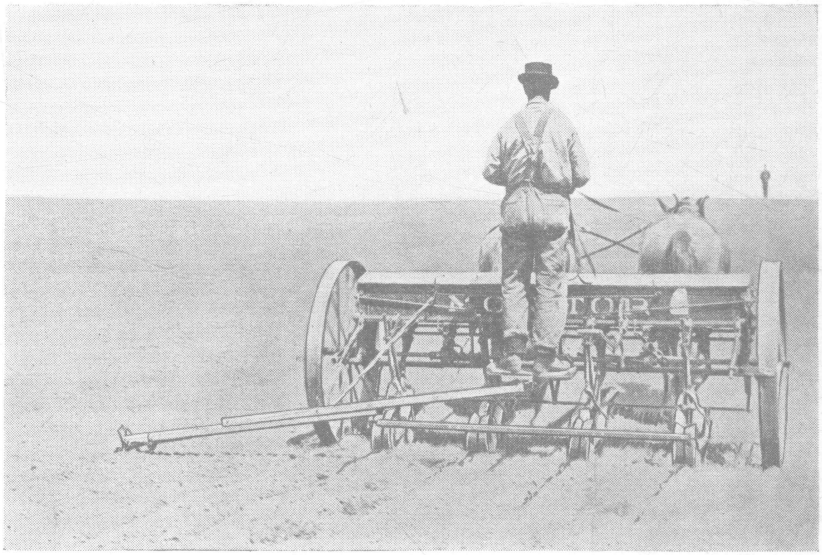

Fig. 9.—Early seeding of beets results in higher yields and less conflict of labor with other crops.

There are added advantages in planting early. The growing season is lengthened from fifteen to twenty days, which is conducive to increased tonnage and sugar storage. Also, fields may be replanted if the first seeding does not give a satisfactory stand. The rainfall in May insures a uniform germination of seed and early growth, and rapid early growth reduces losses from disease.

Rate of Planting.—The recommended rate of seeding is 15 to 17½ pounds per acre. Higher rates were more necessary in the past than at present because the sugar companies, furnishing the seed, demand and obtain for distribution a better grade of seed than

was used in the past. Practically all sugar beet seed is imported from European countries. The seed breeders and growers from whom the seed is purchased are as careful in their inspections as to purity, quality, and germination as is the Ohio Seed Improvement Association with its certified grain crops.

Spacing.—Carefully conducted experiments by the Continental Sugar Company show that it is impossible consistently to obtain high acre yields unless the beets are closely and properly spaced. Results in northwestern Ohio over a period of years show that the average weight of individual beets has not measurably varied from 1.4 pounds, and that in order to secure yields of 16 or more tons per acre, it is necessary to plant the beets in 22-inch rows with 12-inch spacing of plants in the row.

Fig. 10.—Sugar beets should be blocked regularly and thinned, so that thrifty plants are left properly spaced.

The spacing of plants 22 by 12 inches, with a perfect stand, would result in more than 23,000 plants per acre. The present average stand is 60 per cent, or approximately 13,000 plants per acre. The average acre yield for this 60 per cent stand is slightly over 9 tons. While it is improbable that a perfect stand of beets could be attained, it is not impossible to secure a stand of 80 to 90 per cent, which would materially increase the yield over the present average. Most of the factors limiting a more perfect stand can be avoided if proper precautions are observed.

The hand labor begins with the blocking and thinning. It is essential that the work done by hand labor be closely supervised and directed, because the beet yields may be materially reduced if this work is neglected. The beets should be blocked regularly and thinned so that thrifty plants are left properly spaced. A few extra

privileges granted to the hand labor will usually result in more tons of beets per acre at harvest time.

Cultivation of Sugar Beets

Sugar beets respond to frequent cultivations. The number of cultivations varies from five to eight. Cultivation destroys weeds and improves the tilth of the heavy beet soils. If the ground has been properly firmed and leveled before the beets are planted, the first cultivation can be started as soon as the rows of young beet plants are visible. The four-row cultivator is equipped with crow

Fig. 11.—Frequent and late cultivations are important for increasing yields.

feet or knives which run about 1 inch under the surface. This operation destroys the weeds between the rows. This cultivation should be followed by a cultipacker or a roller to pulverize the small clods, to firm and level the soil. For the subsequent cultivations bull-tongue attachments are used. These small shovels should be set to stir the soil to a depth of 3 or 4 inches for the first cultivation; thereafter the depth should be gradually decreased as the size of the beet increases.

The cultivations should be of such frequency that a fine surface is maintained and all cracks in the soil filled. During this time the beets will be blocked and thinned and should be hoed sufficiently to

keep all weeds out of the row. Cultivations at the proper time and depth will result in increased yields.

Harvesting Sugar Beets

Sugar beets should not be harvested until mature. Time of maturity depends on several factors, such as date of planting, fertility of the soil, weather conditions (temperature and distribution of rainfall), etc. In Ohio most of the beets are harvested between October 1 and November 15. Ordinarily, when the lower leaves begin to turn yellow and die, the beets are mature. When immature beets are harvested the sugar content is low. As the beet nears maturity it uses less and less sugar in enlarging its growth. The excess sugar is stored in the root. The rate of sugar increase during the time of maturity may be ½ of 1 per cent each week. However, this rate of storage is variable and depends on weather conditions.

Lifting.—Several types of beet lifters are used with equal success. These lifters are fitted with one or two sharp, curved knives which run to the side and curve under the row. They loosen the beet from the lower roots and partially lift it out of the ground. The lifter may be drawn by a team of horses or by a tractor. The beets are then pulled by hand and thrown into piles, or laid in straight rows with the tops in one direction. The tops are cut off just under the lowest leaf scars.

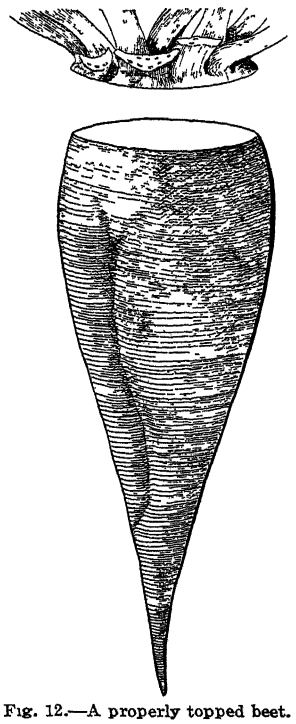

Fig. 12.—A properly topped beet.

It is essential that the topping be properly done, as the impurities in the crowns, if left on the beets, lessen the sugar extraction. Approximately, every pound of impurity decreases the sugar extraction by 1½ pounds. When topped, the beets from 16 rows are thrown in piles, which should be covered with beet tops to prevent evaporation and to protect from frost.

This method of lifting and topping may be superseded by use of a tractor-drawn combined topper and lifter, which drops the beets in piles and bunches the tops. In some areas this machine has been used successfully and in others it has not proved so efficient as pulling and topping by hand, since it breaks off some of the beets and leaves a part of them in the ground.

Fig. 13.—A combination topper and lifter in action.

Delivery.—Before definitely deciding whether to grow beets, it is important to consider the distance over which the beets must be transported, either to a loading station or to the sugar factory. Sugar beets are heavy and the tonnage per acre is relatively high

Fig. 14.—Loading beets in the field.

when compared to the yield of other farm crops. Ordinarily, it is not economical to transport beets with a team and wagon more than three or four miles. If the distance is increased to six miles, the excess cost of transportation is usually from 50 to 75 cents per ton. For distance of more than three or four miles the grower should use a motor truck, which will save considerable time and expense in delivering the beets.

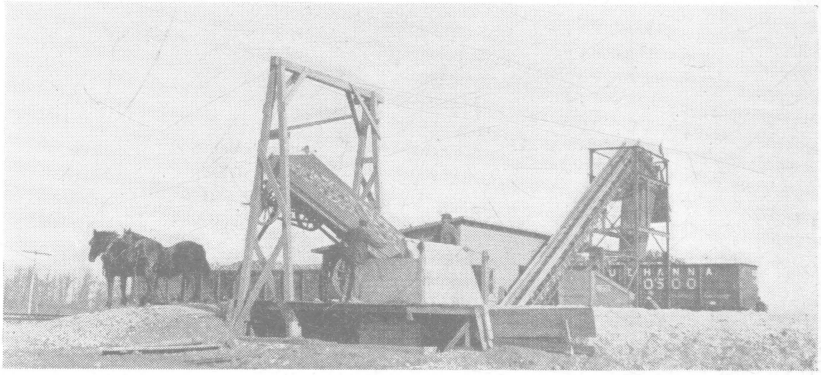

Fig. 15.—Sugar beet dump and loading station.

Rotations for Sugar Beets

The farm practice of growing crops in rotation is centuries old. When soils were in their virgin state, their resources were almost unlimited, but years of continuous grain growing have reduced the humus and nitrogen to so low a point that the maintenance of the necessary soil constituents demands a better cropping system. Aside from maintenance of soil fertility, many other factors necessitate a rotation of crops. Such factors are: insects, diseases, and the presence of certain weeds.

Careful observation of the most successful farming systems shows that they include a definite rotation and a crop sequence that results in high yields. Under these systems the fields are of equal size and the acreage of each crop is the same each year. By this method, fertility of the soil is maintained, legumes are grown regularly, sufficient livestock is kept to consume all forage and by-products without waste, and each year a definite amount of manure is produced and can be applied to the crop needing it most. A good rotation for northwestern Ohio should include a cash crop. The growing of sugar beets will furnish this cash income. However, deep rooted crops should be alternated with shallow rooted crops to more efficiently use all of the soil and to maintain proper soil

sanitation. The arrangement of these crops should be such that the labor is evenly distributed throughout the season.

The sugar beet is not considered an exhausting crop, but it does require a fertile soil. The fertility of the soil can best be maintained by growing legumes frequently in the rotation. Practical experience teaches us that the more frequently legumes are grown in the rotation, the more the yields of non-legumes are increased.

With the preceding points in mind, a standard five-year sugar beet rotation, including two legumes, is recommended to the beet grower of northwestern Ohio:

First year	Corn
Second year	Sugar beets
Third year	Oats or barley
Fourth year	Alfalfa
Fifth year	Wheat (sweet clover)

The sweet clover is utilized as a green manure for the corn crop. In this rotation 20 per cent of the total crop area on the farm is in beets each year. Where not over 10 per cent of the crop acreage is desired for beets, the other half of the field can be utilized for spring-seeded grain, soybeans, tomatoes, or cabbage. Under this latter plan beets would be grown on the same ground once in ten years.

Additional rotations suggested are:

1. Four-year rotation	Corn, beets, oats, alfalfa
2. Five-year rotation	Beets, corn, oats, wheat, clover
3. Five-year rotation	Corn, soybeans, beets,oats, alfalfa
4. Five-year rotation	Corn, beets, oats, alfalfa, alfalfa

Fig. 16.—Increased growth (on the right) the direct result of sweet clover in the rotation compared with alsike (on the left).

When beets follow clover, fall plowing is recommended on account of the prevalence of cutworms in spring-plowed sod ground.

In the preceding paragraphs, the necessity for a definite crop rotation and for inclusion in it of legumes and a cash crop in order to strike the proper balance for successful farming, has been pointed out. This means that if beets are included in the rotation they should be grown each year.

Value of Sugar Beet Tops

In northwestern Ohio, little or no attention has been given to the value of beet tops, either for the fertilizer constituents contained or their value as a feed for livestock. No doubt this condition is due largely to the high cost of labor and the amount of time available, and to the fact that other good forage crops such as corn and alfalfa are available. As has been previously stated, in harvesting beets the crown is cut off because the salts they contain lower the sugar extraction. According to Henry and Morrison*, if the tops and leaves are gathered carefully they will weigh approximately half as much as the marketed beets. In Ohio, the total dry weight of tops and leaves probably would not exceed that of other crops grown for forage alone. However, the quantity is variable; the amount of growth will depend on soil fertility, time of planting, amount of rainfall, and many other factors.

Henry and Morrison further state that stock may be grazed on the tops, or the tops may be ensiled, in which case the soil should be shaken off. In the western states the beet tops are ensiled in pits with alternate layers of straw. If ensiled they should be gathered before drying out, and well packed. It is also pointed out that the mixture of straw makes the ensilage, when fed, less purgative. The ensilage is further improved by adding 5 pounds of salt to each ton of tops. Good results are obtained in feeding the silage to stock in combination with hay and other feeds to balance the ration. The daily ration consists of not over 30 pounds of beet top silage for cattle, nor more than 3 pounds for sheep.

The beet top silage is considerably less valuable than good corn silage. Two years' feeding trials as reported by Henry and Morrison showed that when limited amounts of beet top silage were fed, the value was approximately $2.39 a ton as compared with $4.00 a ton for corn silage. The average beet tops, containing 28.8 per cent dry matter, 1.4 per cent crude protein, 7.3 per cent carbohydrates, and 3 per cent fat, have a nutritive ratio of 5.7.

Due to the amount of mineral elements contained, beet tops are valuable as a fertilizer. The ash is relatively high and they con-

* Feeds and Feeding.

tain about 10.2 pounds of nitrogen per ton. In order to conserve their fertility value, if left in the field, the tops should be evenly spread and plowed under as soon as possible. If fed to stock, the fertilizer elements are returned to the soil in the form of manure.

Sugar Beet Diseases and Their Control

By H. C. YOUNG,
Chief, Department of Botany and Plant Pathology, The Ohio Agricultural Experiment Station.

The growing of sugar beets at a profit is becoming increasingly difficult each year, and disease is largely responsible. The cause of this rapid increase in disease is somewhat difficult to explain. However, when it is realized that a great many disease producing organisms are introduced with seed, and that our beet seed is shipped almost entirely from widely scattered regions of Europe, it is to be expected that we would have about all the diseases known to that crop. The beet seed ball is peculiarly adapted, structurally, for the harboring of disease germs.

This explanation of the increase of disease is not quite satisfactory when it is realized that beet growing is successful in Europe even though beets have been grown there for centuries, and in the midst of all the parasites that we have, and more. This fact alone, however, gives us some promise of what we might expect in the future. In Europe, the parasite and host (the beet) have lived together so long that, by gradual adaptation, there has resulted a sort of equilibrium by which both live without serious loss to either. When both parasite and host are removed from their adjusted habitat, extreme variations are apt to occur.

The change in environment probably has more effect on the growth habits of the beet than of the parasite, thus causing a greater variation in susceptibility or resistance. The fact should be added also that the margin between susceptibility and resistance of host to parasite is very little. In this connection, keep in mind that a growing plant is usually surrounded by hundreds of microorganisms in which the margin between parasitism and saprophytism (living on dead organic material) is exceedingly small. This is the reason that so many beet disease epidemics are governed by weather, cultural, and soil conditions. A normally growing beet is not so susceptible to destruction by disease.

It is no longer necessary to discuss in a bulletin for beet growers the loss caused by disease. The limiting factor in beet growing is disease, and the industry will soon pass out completely unless the growers use all available information in an attempt to control the

more serious troubles. It is regrettable that more definite control measures are not available, but the problems are difficult in that many of the diseases are caused by root destroying parasites that live for long periods in the soil, whether beets are there or not. Moreover, it is difficult to find a substance which, when added to the soil, will kill the parasite and not injure the roots of the beet.

It must be constantly kept in mind that the diseases of beets are caused by parasitic organisms and, for an intelligent application of control measures, a grower must necessarily be somewhat familiar with the nature of these parasites. Only those parasites that are most destructive will be included here and, for convenience in discussion, will be divided into two classes, those attacking the *roots* and those attacking the *leaves*.

Diseases of the Beet Root

Damping off.—The most serious root damage occurs in the spring, and the first disease is what is known as "damping off." There are probably several parasites involved, all producing about the same results, namely, the killing of the plant just at or slightly above the surface of the ground. These organisms begin working on the young beet plants before they come through the ground and, in many cases, kill them before they ever come up.

Their destructiveness is governed to a considerable extent by soil and weather conditions. Poorly drained soil favors damping off, as does cool, damp weather, and the more serious losses occur when these two conditions are combined. The organisms involved are not specific for beets, but are parasitic, or live on many other plants or on organic matter in the soil. Consequently, they are usually present in more or less abundance and when conditions are favorable become destructive.

Control Measures.—The control measures for the organisms are not very specific. It has been found that a judicious crop rotation is the best control. Corn preceding beets is favored because that crop is a host for very few, if any, of these parasites and the latter are rapidly thinned out during its growth. Good drainage and a well fitted seedbed usually check damping off.

Black root.—Probably the most serious disease of the beet is the one generally called "black root." It is this disease that is largely responsible for poor stands and the plowing up of fields planted to beets, because, in many seasons, it reduces the acreage tremendously. For many years it has been on the increase and has. in fact, threatened the industry in many sections.

The name of the parasite causing this disease is still somewhat questioned, there being some doubt as to its being *Phoma betae.* However, the symptoms are thoroughly familiar to most beet growers and will be mentioned here only as they can be contrasted with the damping-off disease. It is possible that Phoma may cause a damping off, but its usual attack is below the surface of soil, and it gradually turns the entire root black, hence the name "black-root."

The attack of the parasite may take place shortly after the seed germinates and it may kill the plant outright before it comes through the soil. More frequently, however, the infected beets come up and linger along, some dying, or making but little growth, and others completely recovering. In many cases the tap root rots off entirely and new roots come out at the crown. This usually results in a small, irregularly shaped beet. When a beet recovers, the fungus usually continues to grow slowly with it. When such beets are used for growing seed, the parasite follows up the stalk to the seed ball, and then produces its spores, and as a result, few lots of seed are free from it.

Another source of the disease comes from the soil. The parasite is able to live on organic matter for four or more years.

Control Measures.—The organism causing black root is sometimes regarded as a weak parasite. The beet plant may become infected very early and, under favorable growing conditions, suffer but little injury. In other words, a normally growing beet is either resistant or is able to grow in spite of the parasite. On the other hand, if the beet has had a poor start, or adverse weather sets in, or the beet is retarded in growth for any reason, the parasite gets the upper hand, and loss is incurred.

The problem, then, is to keep the beet growing normally through this early period. Ways of doing this are:

1. The five-year rotation given on page 23. Experiments at the Paulding County Experiment Farm have shown that black root decreases as the rotation is lengthened to five years.

2. Seed treatment. This has been recommended quite generally but, in the main, has failed to give satisfactory results. Possibly, it helps. The following treatments have been used:

   (a) The use of disinfecting chemicals, such as formaldehyde, Semesan, copper compounds, etc., at the rate of 4 to 5 ounces to 1 bushel of seed.

   (b) The beet treatment, a difficult method to apply.

3. Application of fertilizers as given on pages 14 to 16. Active nitrogenous fertilizers induce rapid growth of the beet through this early period, and have been effective in controlling the disease.

The application of 500 pounds of common salt per acre has given good results. (Experiments conducted by the Continental Sugar Company show that salt in this amount gave better stands and increased yields.)

The control measures recommended are all good cultural practices and even in the absence of disease, increased yields in beets would be obtained. The hope of obtaining a compound which, when added to the soil, will kill the parasite and not injure the beet root, is rather remote. An extensive experimental program for the development of better control measures is under way.

OTHER ROOT TROUBLES:

1. Rhizoctonia root rot is often very destructive to the beet crop. The disease first manifests itself by the abnormal wilting of the outer leaves in the daytime. At first, the leaves will recover at night. Later, all leaves wilt, turn brown and die. The fungus enters the beet well below the surface of the soil and grows upward inside the outer layer of the beet, killing the cells. Eventually, the outer layer becomes sunken, forming many definite cankers.

Control.—Very little information is known as to definite control measures for this disease. The following will aid in control:

(a) Drainage
(b) Beets following corn in a five-year rotation
(c) The use of lime (sugar factory lime is recommended.)

2. There are several bacterial soft rots of the beet. They are usually spasmodic in their appearance and, in general, cause but little damage. They have received but little study, and control measures are indefinite.

3. There are several other root diseases that are sometimes serious in other sections but are rarely found doing damage in Ohio. Crown gall, scab, and nematode galls are examples.

DISEASES OF THE LEAF

Cercospora leaf spot.—One of the most destructive diseases of the sugar beet is the Cercospora leaf spot. Again, it is scarcely necessary to discuss the symptoms of this disease with beet growers. The loss caused is frequently tremendous and comes about as follows: (1) a reduction in tonnage; (2) a reduction in sugar content; (3) an increase in tare because of the high crown of the beet —as the lower leaves are killed the crown is raised by new leaves being formed; and (4) lower purity.

The seriousness of the disease is greatly affected by weather conditions. A period of hot, dry weather, followed by hot moist

conditions, enhances the development of the fungus. The losses are greater the earlier the disease gets under way, usually in late August or early September.

Control Measures.—1. Deep fall plowing usually reduces the chances for an epidemic.

2. Rotation; an unrelated crop is not attacked by the fungus and it does not live in the soil longer than two years.

3. Spraying with a 4-6-50 bordeaux mixture or dusting with a 20-80 monohydrated copper sulfate and fresh hydrated lime will control it. It will require from four to six applications, beginning when the disease first starts, and continued at ten day to two-week intervals. The cost will be about $1.50 per acre per application.

4. A very extensive effort is now being made to develop resistant varieties of beets.

OTHER LEAF DISEASES.—There are several other diseases of the leaf, but they are of little economic importance in Ohio.

Sugar Beet Insects and Their Control

By T. H. PARKS,
Extension Specialist in Entomology

FLEA BEETLES

The striped flea beetle *(Systena blanda)* is at times a very serious enemy of sugar beets; it is most abundant during periods of drouth. The beetles attack the beet seedlings while they are still quite small. They eat numerous small holes in the tiny leaves and may either badly cripple the very young plants or destroy them outright in years when the insect is numerous. Besides beets, they feed upon tomatoes, turnips, carrots, corn, potatoes, radishes, eggplant, cabbage, and melons. They are found feeding commonly on many weeds, chief among which are lambs' quarter, pigweed, chickweed, ragweed, plantain, purslane, and cocklebur.

The larvae or young are grub-like and feed on the roots of corn, lambs' quarter, Jamestown weed, and probably other weeds. They pupate in cells in the soil. The beetles emerge in the late spring or early summer. The eggs are laid in the soil by the parent beetles and these hatch into the grub-like larvae. The beetles migrate from weeds to cultivated crops and will soon distribute themselves over a beet field. They travel from plant to plant by jumping, for which they are well adapted, and this habit of travel gives the insect its name. There are two or three generations per year.

Control Measures.—Control consists largely of methods of prevention. Keeping down weed growth will reduce the number of beetles that breed on these plants and later enter the beet fields. When beetles are observed entering fields, frequent rolling or use of the cultipacker is of some value while the beets are very small. Rolling should be done during mid-day when the plants are dry.

Some success in controlling severe outbreaks has been reported by the Continental Sugar Company of Toledo, Ohio. In their work a mixture composed of 10 pounds of finely pulverized hydrated lime and 1 pound of Paris green was dusted on the rows of beets. They have also repelled the beetles by dusting with hydrated lime alone. The lime serves as a repellant only and must be repeated as necessary to keep the plants dusted. A dust mixture of 1 part of calcium arsenate and 10 parts of hydrated lime has been used successfully by some growers. The dust should be applied where there is no wind and preferably when dew is on.

A spray composed of bordeaux mixture and calcium arsenate or arsenate of lead is the standard control for flea beetles on garden vegetables. This is not recommended for sugar beet fields because of the difficulty of thoroughly spraying such small plants and the damage such sprayers would cause to the crop in beet fields.

Copper-lime dust with arsenical added, while inferior to the liquid bordeaux, would afford some protection, but its value over the use of lime, or lime plus an arsenical, would make its use questionable as an economical control method.

APHIDS

During the summer of 1927 aphids (plant lice) caused much damage to sugar beets in some northern Ohio fields. The lice collected on the under sides of the beet leaves, where they multiplied so rapidly that the beet leaves turned yellow from their feeding. Such injury greatly dwarfs the growth and lowers the yield and sugar content of the beet.

Control Measures.—Control of aphids on field beets is quite difficult. Spraying with a contact spray must strike the insects to be effective. This is difficult to do, and, owing to the infrequency of attack, suitable spraying machinery for aphis control is not deemed necessary for beet growing.

Dusting the insect with home-made nicotine dust, carrying not less than 3 per cent of nicotine, is the most dependable method to use. The dust should be applied with a good hand or power duster when there is no wind and when the temperature is high. Directions for making nicotine dust from lime and nicotine sulfate solu-

tion can be supplied upon application to the extension entomologist of the Ohio State University.

Aphids are usually kept under control by weather conditions and insect parasites and predators. It is only when the weather is abnormal and unsuited for rapid parasite development that these insects become a pest of vegetable crops.

GRASSHOPPERS AND CUTWORMS

Grasshoppers at times cause serious damage to sugar beets. They enter beet fields in late summer from meadows and pastures where they develop from eggs laid in the undisturbed ground. (Eggs are not deposited in cultivated fields.) They hatch into tiny grasshoppers that feed and develop in almost any of the cultivated crops and weeds.

Cutworms are most prevalent in spring plowed sod ground, and frequently cause considerable damage to beets by cutting off the young beet plants at or near the surface of the ground.

Control Measures.—Grasshoppers thrive best during dry seasons. They are held in check by rainy weather and rarely call for artificial control. When this is necessary, the use of a poisoned bait is quite economical and effective.

Since cutworm damage occurs early in the growing season, they may be partially controlled by frequent cultivation. The cultivation exposes the cutworm to the hot sunshine. Poison bait has been used effectively and economically in controlling cutworms. For both the grasshopper and cutworm the same poison bait is used. This is made as follows:

(a) Bran ..... 20 pounds

(b) White arsenic (not arsenate of lead)
or
Paris green ..... 1 pound

Mix the bran and poison dry until well mixed and poison is adhering to each particle of bran. Prepare a dilute sirup as follows:

(a) Cheap molasses ..... 2 quarts
(b) Amyl acetate (flavor).... ¾ ounce
or
Ground oranges (fruits)... 4 fruits
(c) Water ..... 3 gallons

Stir the mixture well and pour over the bran mixture while stirring, to moisten all particles of the bran. Add enough additional water to make thoroughly moist but not soggy. Scatter the bait broadcast where the grasshoppers are feeding. Scatter it thinly and evenly so that poultry or birds will not pick it up. For grasshoppers apply during early morning before insects begin feeding,

and for cutworms, late afternoon or evening—as they feed after sundown. The above amount is enough to cover 3 or 4 acres of land. The grasshoppers and cutworms will feed upon the bait and die.

The 16-Ton Sugar Beet Club of Ohio

1. The 16-Ton Sugar Beet Club is open to any farmer in Ohio more than 19 years of age.
2. Enrollment in this club stops July 1, and each county must have at least four entries.
3. A 50-cent entry fee will be charged to each one enrolling in the club.
4. Acreage of sugar beets, to be eligible for this club, must be not less than 5.
5. The 5-acre plot must be in one piece, with regular sides so it can easily be measured accurately. It may be part of a larger field.
6. A county champion will be selected in each county at the end of the season.
7. Any man in the state who succeeds in producing an average of 16 net tons of sugar beets with a minimum sugar pack of 4,200 pounds per acre on his 5-acre plot will be entitled to membership in the 16-Ton Sugar Beet Club of Ohio, whether he be the winner in his county or not.
8. The State Champion will be the man who secures the highest net tonnage with a minimum sugar pack of 4,200 pounds per acre and will be awarded a grand championship cup in addition to any other award he may receive. The winner in each county, provided he has a yield of 12 tons with sugar pack of not less than 3,200 pounds per acre, will be awarded a county championship medal.
9. All awards will be made at The Ohio State University during Farmers' Week. It is expected that winners be present to receive these awards.
10. The cooperator agrees to keep a record of the labor and expense involved in producing his crop, on blanks furnished to him, and at the end of the season send this record together with a copy of official weights on his yield to the County Agent of his county, who in turn, will forward the report to The Ohio State University.
11. The cooperator agrees to secure seed from the company for which he grows beets in order that the source of seed may be known.
12. Yields to be determined in the following manner:
    (a) The 5-acre plot must be measured accurately by the County Agent or a referee appointed by him, and the entire crop on this plot weighed.
    (b) At the time of harvesting a sample consisting of at least 6 beets, secured by taking 2 large, 2 medium size, and 2 small beets from the field. This sample must be sent immediately to The Ohio State University, where sugar content will be determined.
    (c) Before determining the sugar content, this sample should be tared in the same manner as at the loading station.
    (d) In shipping, each beet should be placed in a special paper bag, and all packed securely in a box.

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